Effect of substrate porosity and doping concentration on the thermochromic properties VO_2

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Abstract

VO_2 has a semiconductor-metal reversible transition (SMT) phase at Tc=68°C, which has been used for several applications [1-2]. In this work, the changes in the VO_2 transition temperature are studied as a function of doping concentration of TiO2 nanoparticles (1 and 4% of TiO_2). The optical response of the composite sample formed over porous silicon (PSi) substrate was measured as a function of temperature with respect to the control sample over crystalline (cSi) substrate.

Preparation of VO_2/PSi structure

PSi layer was prepared by anodic dissolution applying the current density of 55 mA/cm^2 for 10 s on electrolyte mixture of aqueous HF, ethanol, and glycerol, in 3:7:1 proportion of volume, respectively. The VO_2 was spin coated (2500 rpm for 60 s) onto the PSi matrix followed by annealing under nitrogen atmosphere at 450°C for 60 min [3].

Results

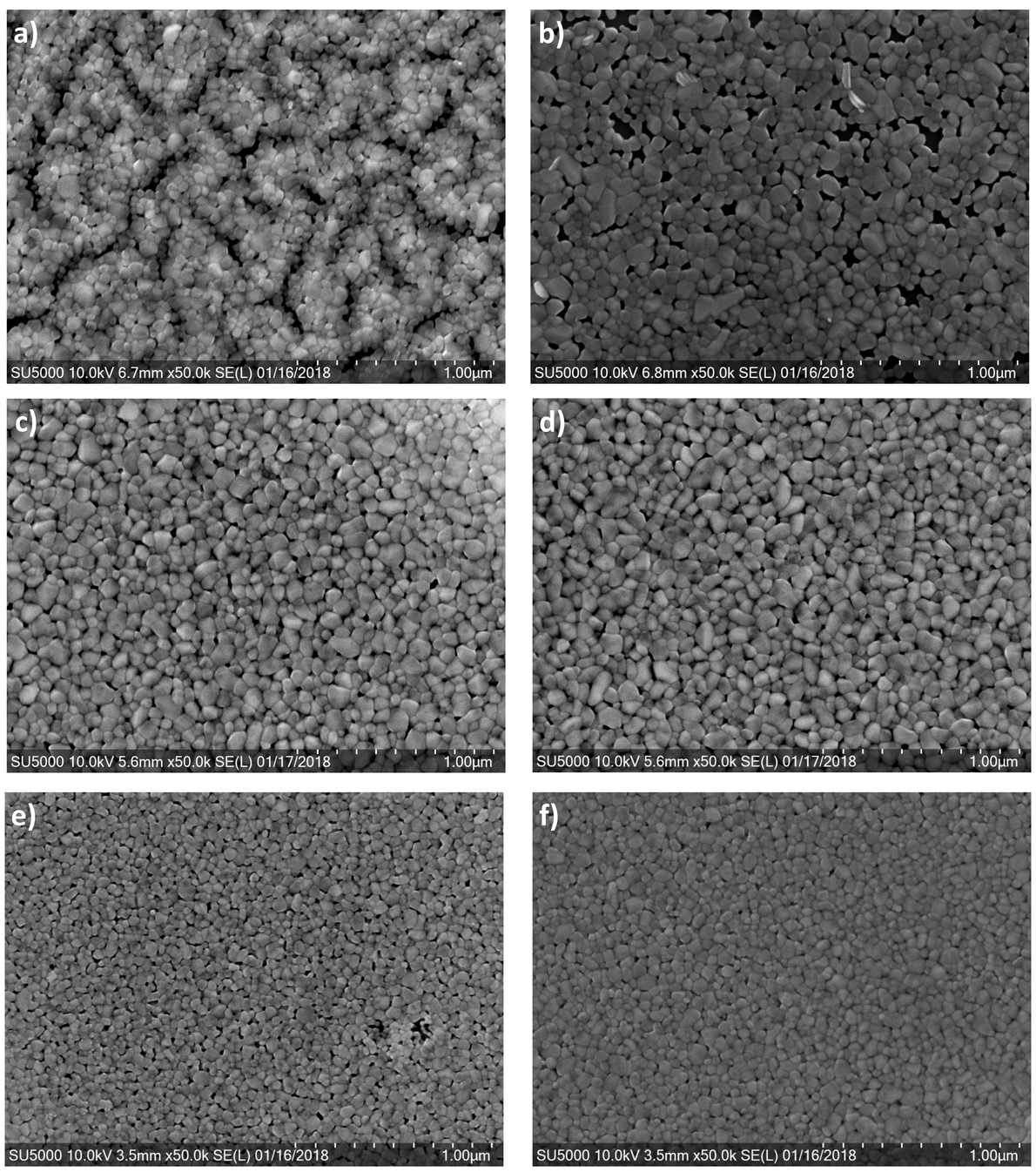
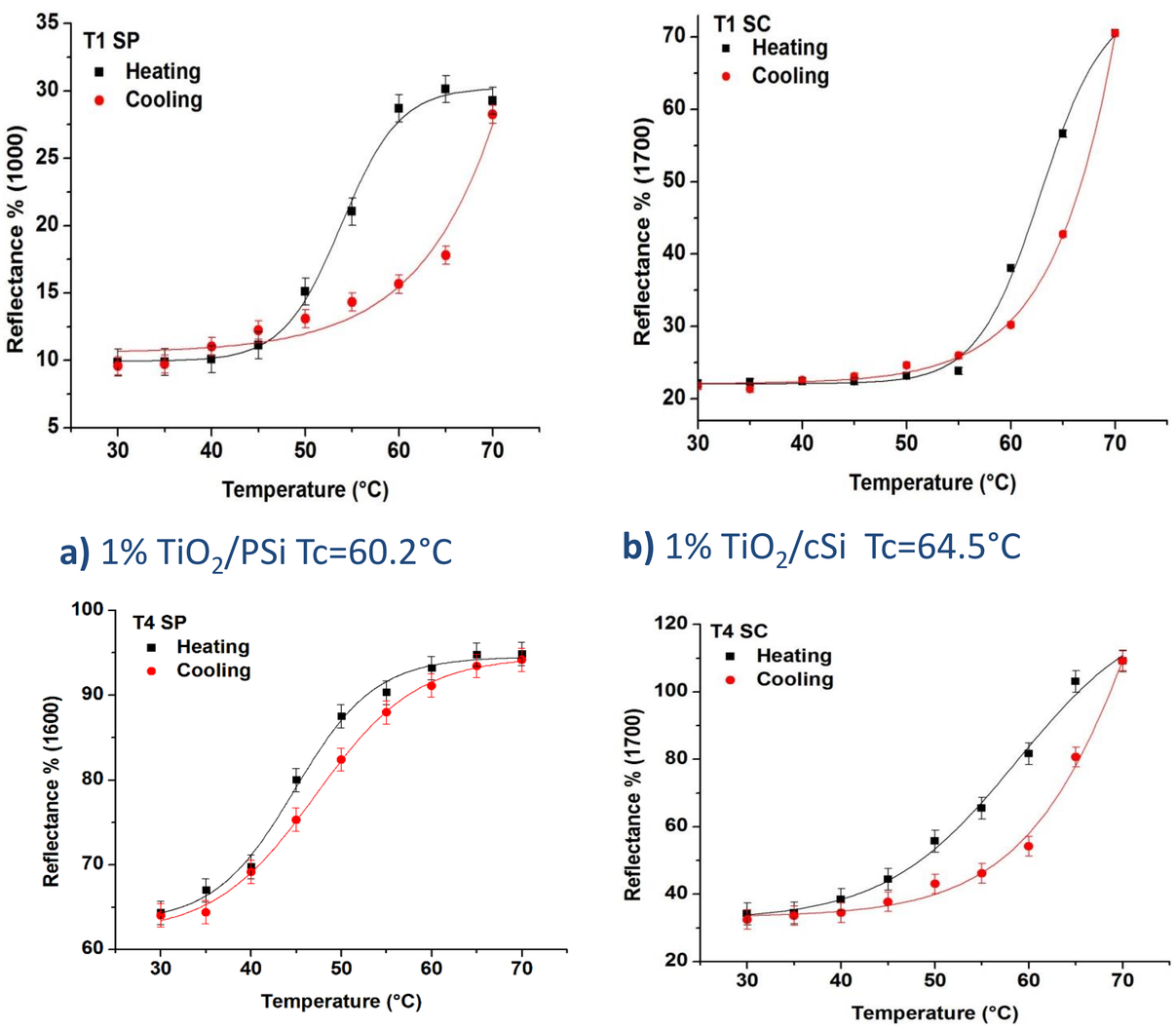


Figura 1. SEM images of undoped VO_2 film on (a) PSi, (b) cSi and (c) doped VO_2 films with 1% TiO_2/PSi, (d)1% TiO_2/cSi, (e) 4% TiO_2/PSi, (f) 4% TiO_2/cSi.

Optical Characterization



a) 1% TiO_2/PSi Tc=60.2°C

b) 1% TiO_2/cSi Tc=64.5°C

c) 4 % TiO_2/PSi Tc=50.6°C

d) 4 % TiO_2/cSi Tc=60.5°C

Figura 2. Hysteresis curve : Reflectance of doped VO_2 films measured at a particular wavelength as a function of temperature.

Conclusions

-An increase in the doping concentration results in the formation of densely packed and more homogeneous films with smaller grain size. This decrease in the grain size has been attributed to the enhanced defect-nucleation site density introduced by doping.

-An increase in TiO_2 concentration, SMT transition temperature of VO_2 films was decreased with an additional increase in surface porosity.

-Contrary to the VO2 films deposited on the cSi substrate, hysteresis loop width is found to decrease for the films deposited over PSi substrates. Attributed to the porous morphology provoking the mechanical clamping and hence contributing to the decrease in the SMT transition temperature.

References

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